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Monta et al.

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(54) **MONITORING SYSTEM, MONITORING METHOD, MONITORING PROGRAM, AND RECORDING MEDIUM IN WHICH MONITORING PROGRAM IS RECORDED**

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G06F 17/30 (2006.01)
G06K 9/62 (2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/00268*** (2013.01); ***G06F 17/30247*** (2013.01); ***G06K 9/00255*** (2013.01); ***G06K 9/00295*** (2013.01); ***G06K 9/00778*** (2013.01); ***G06K 9/6201*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A monitoring system for monitoring a target is described. The monitoring system extracts features of a person's face from an image obtained from the face of the person and determines whether the person's face matches a person included in a list containing facial features of multiple individuals.

4 Claims, 12 Drawing Sheets

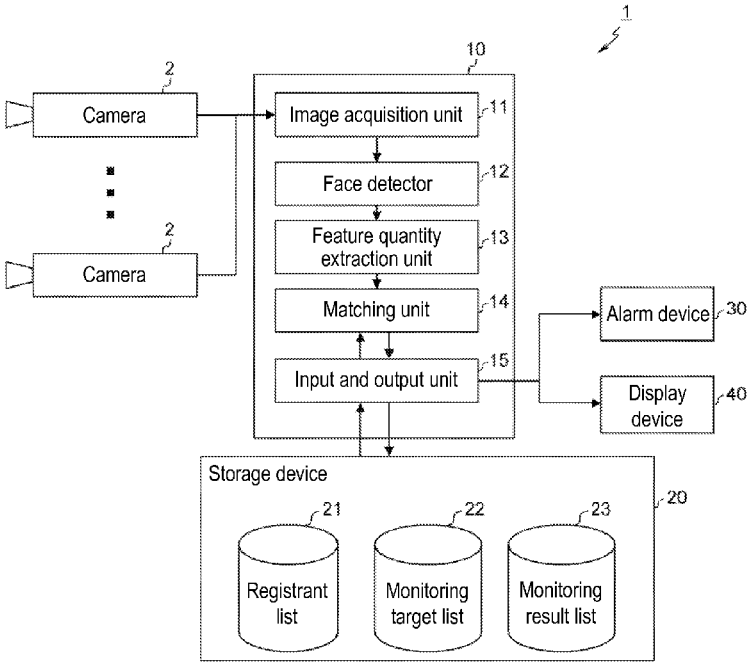


FIG. 1

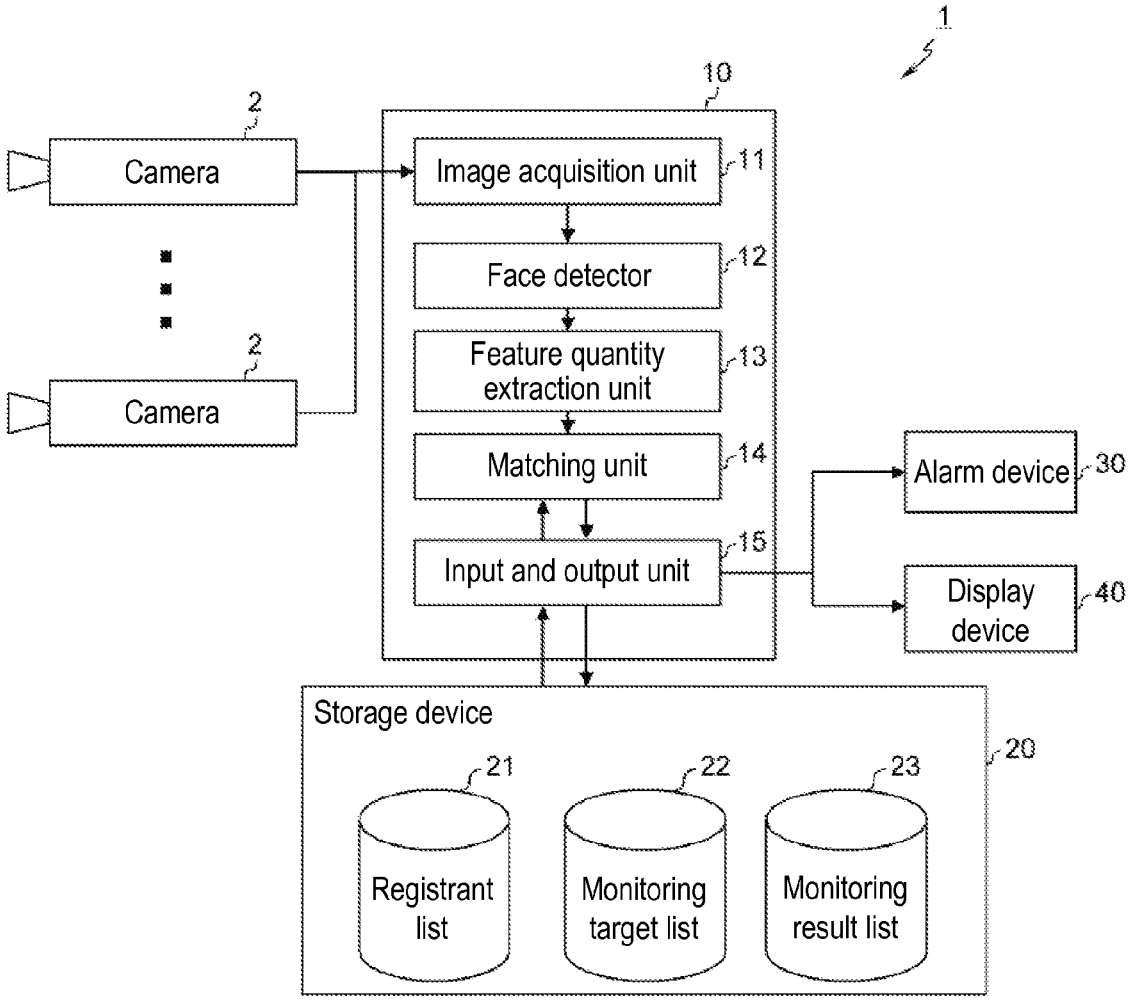

1
10
2
Camera
2
Camera
Image acquisition unit
11
Face detector
12
Feature quantity extraction unit
13
Matching unit
14
Input and output unit
15
Alarm device
30
Display device
40
Storage device
20
21
Registrant list
22
Monitoring target list
23
Monitoring result list

FIG. 2

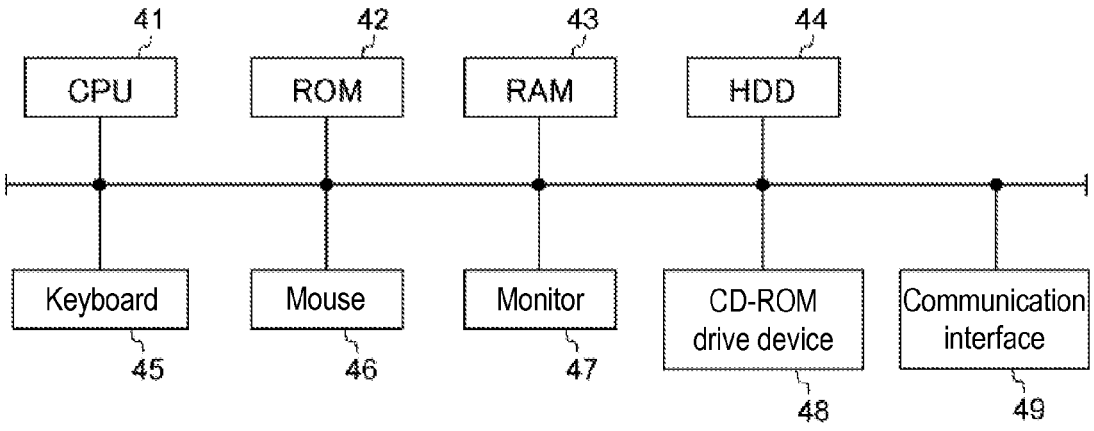

41
42
43
44
CPU
ROM
RAM
HDD
Keyboard
Mouse
Monitor
CD-ROM drive device
Communication interface
45
46
47
48
49

FIG. 3

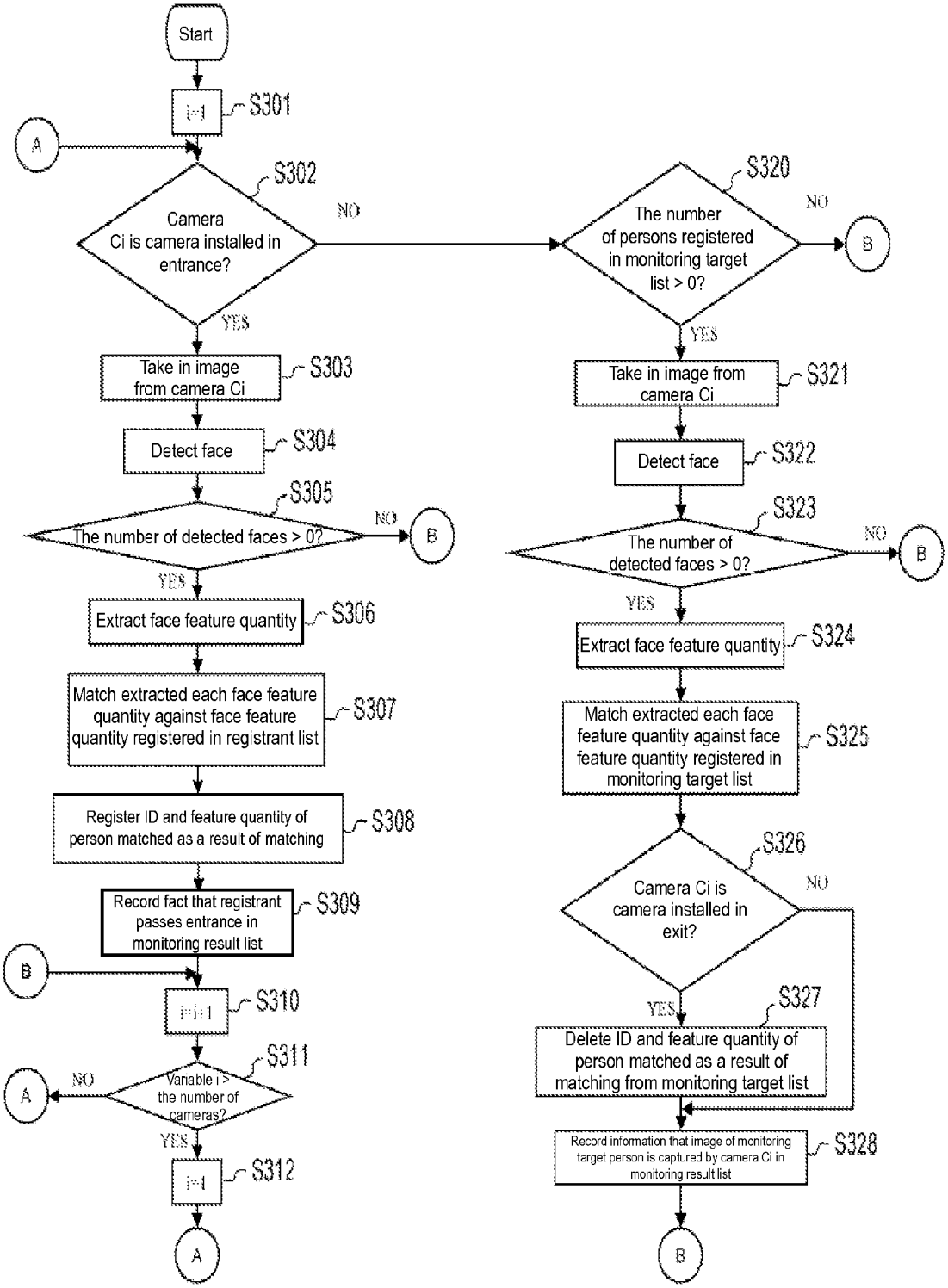

Start
i=1
S301
A
S302
Camera Ci is camera installed in entrance?
NO
YES
Take in image from camera Ci
S303
Detect face
S304
S305
The number of detected faces > 0?
NO
B
YES
Extract face feature quantity
S306
Match extracted each face feature quantity against face feature quantity registered in registrant list
S307
Register ID and feature quantity of person matched as a result of matching
S308
Record fact that registrant passes entrance in monitoring result list
S309
B
i=i+1
S310
S311
Variable i > the number of cameras?
NO
A
YES
i=1
S312
A
S320
The number of persons registered in monitoring target list > 0?
NO
B
YES
Take in image from camera Ci
S321
Detect face
S322
S323
The number of detected faces > 0?
NO
B
YES
Extract face feature quantity
S324
Match extracted each face feature quantity against face feature quantity registered in monitoring target list
S325
S326
Camera Ci is camera installed in exit?
NO
YES
S327
Delete ID and feature quantity of person matched as a result of matching from monitoring target list
Record information that image of monitoring target person is captured by camera Ci in monitoring result list
S328
B

FIG. 4

Date	Clock time	Target person ID	Camera ID	Remarks
2013/6/15	10:02	003	C1	Entry
2013/6/15	10:05	001	C1	Entry
2013/6/15	10:07	003	C2	Sales section ○○
2013/6/15	10:10	002	C1	Entry
2013/6/15	10:12	001	C3	Sales section ××
		...		
2013/6/15	10:35	003	C5	Exit
		...		

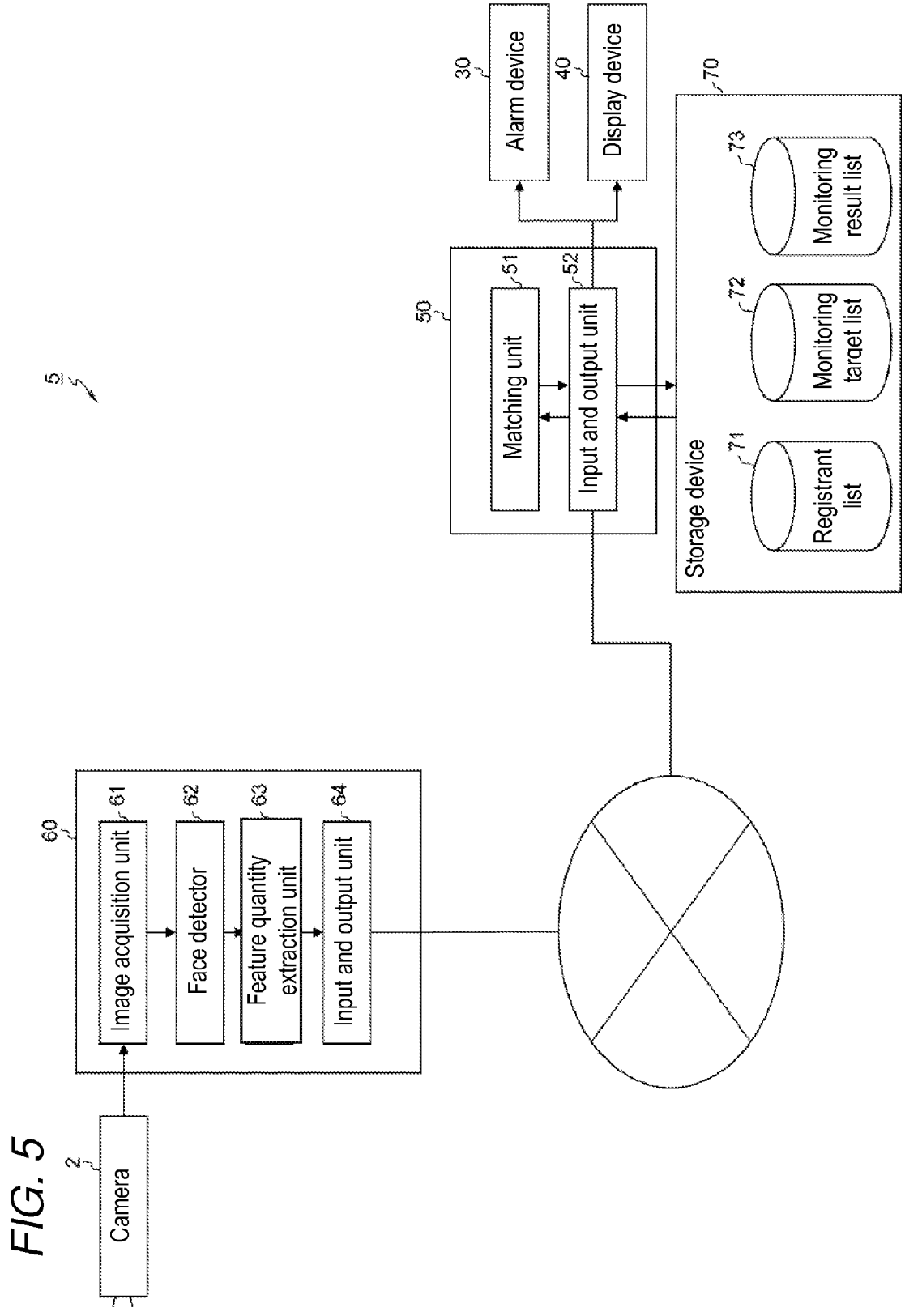
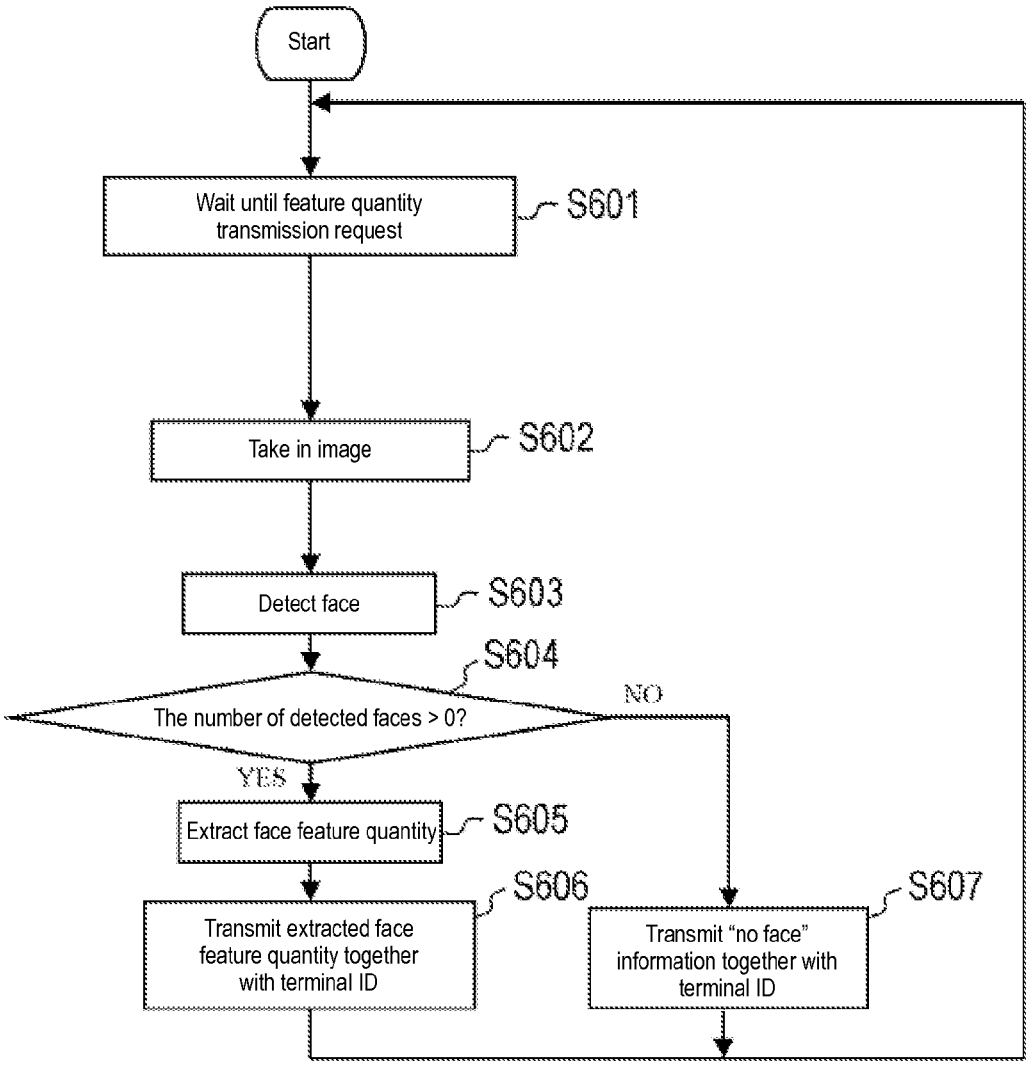

5
2
Camera
60
61
Image acquisition unit
62
Face detector
63
Feature quantity extraction unit
64
Input and output unit
50
51
Matching unit
52
Input and output unit
30
Alarm device
40
Display device
70
Storage device
71
Registrant list
72
Monitoring target list
73
Monitoring result list

FIG. 5

FIG. 6


Start
Wait until feature quantity transmission request
S601
Take in image
S602
Detect face
S603
S604
The number of detected faces > 0?
NO
YES
Extract face feature quantity
S605
S606
Transmit extracted face feature quantity together with terminal ID
S607
Transmit "no face" information together with terminal ID

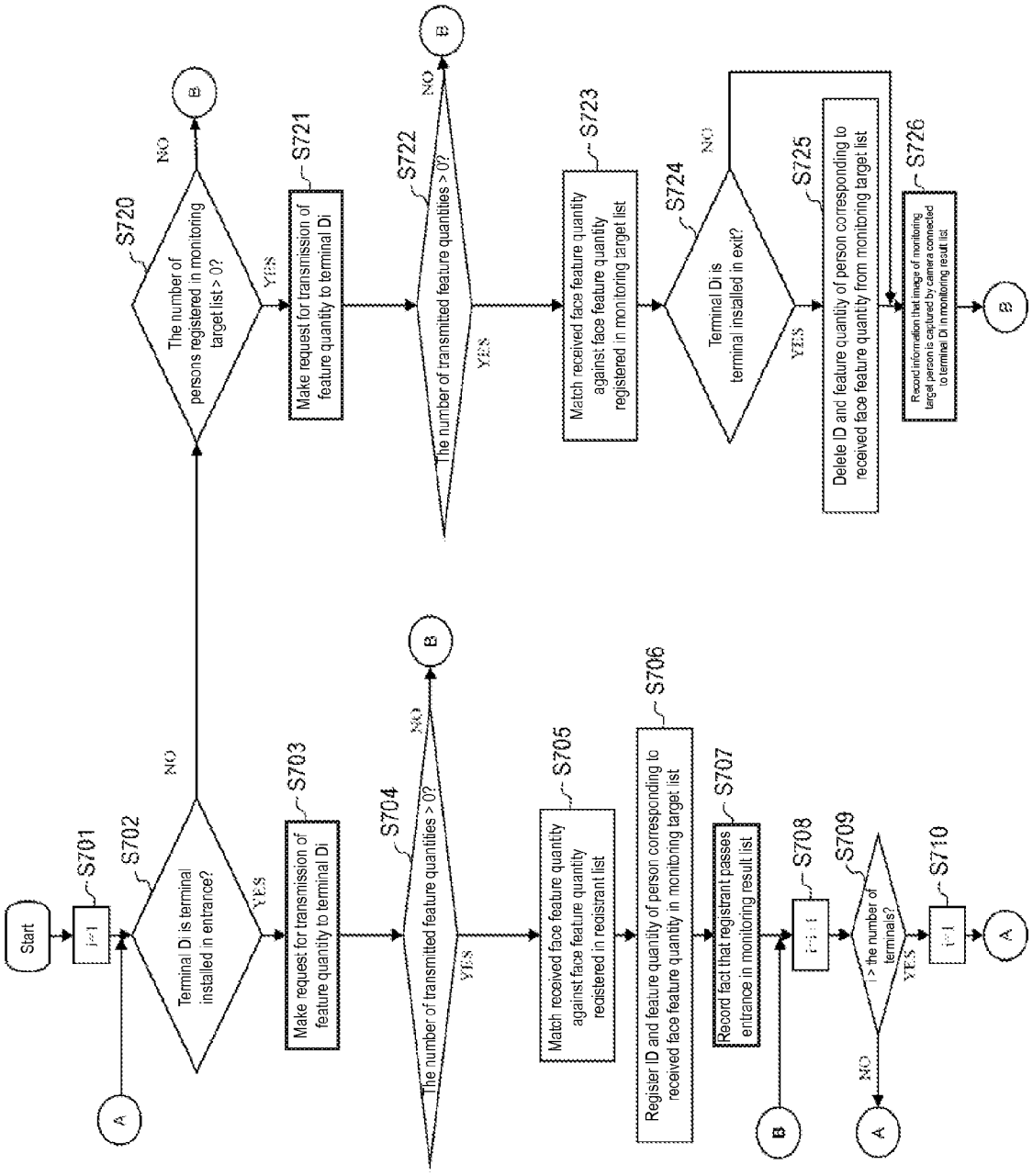

Start
S701
S702
Terminal Di is terminal installed in entrance?
YES
NO
S703
Make request for transmission of feature quantity to terminal Di
S704
The number of transmitted feature quantities > 0?
YES
NO
S705
Match received face feature quantity against face feature quantity registered in registrant list
S706
Register ID and feature quantity of person corresponding to received face feature quantity in monitoring target list
S707
Record fact that registrant passes entrance in monitoring result list
S708
S709
S710
S720
The number of persons registered in monitoring target list > 0?
S721
Make request for transmission of feature quantity to terminal Di
S722
The number of transmitted feature quantities > 0?
S723
Match received face feature quantity against face feature quantity registered in monitoring target list
S724
Terminal Di is terminal installed in exit?
S725
Delete ID and feature quantity of person corresponding to received face feature quantity from monitoring target list
S726
Record information that image of monitoring target person is captured by camera connected to terminal Di in monitoring result list
A
B

FIG. 7

FIG. 8

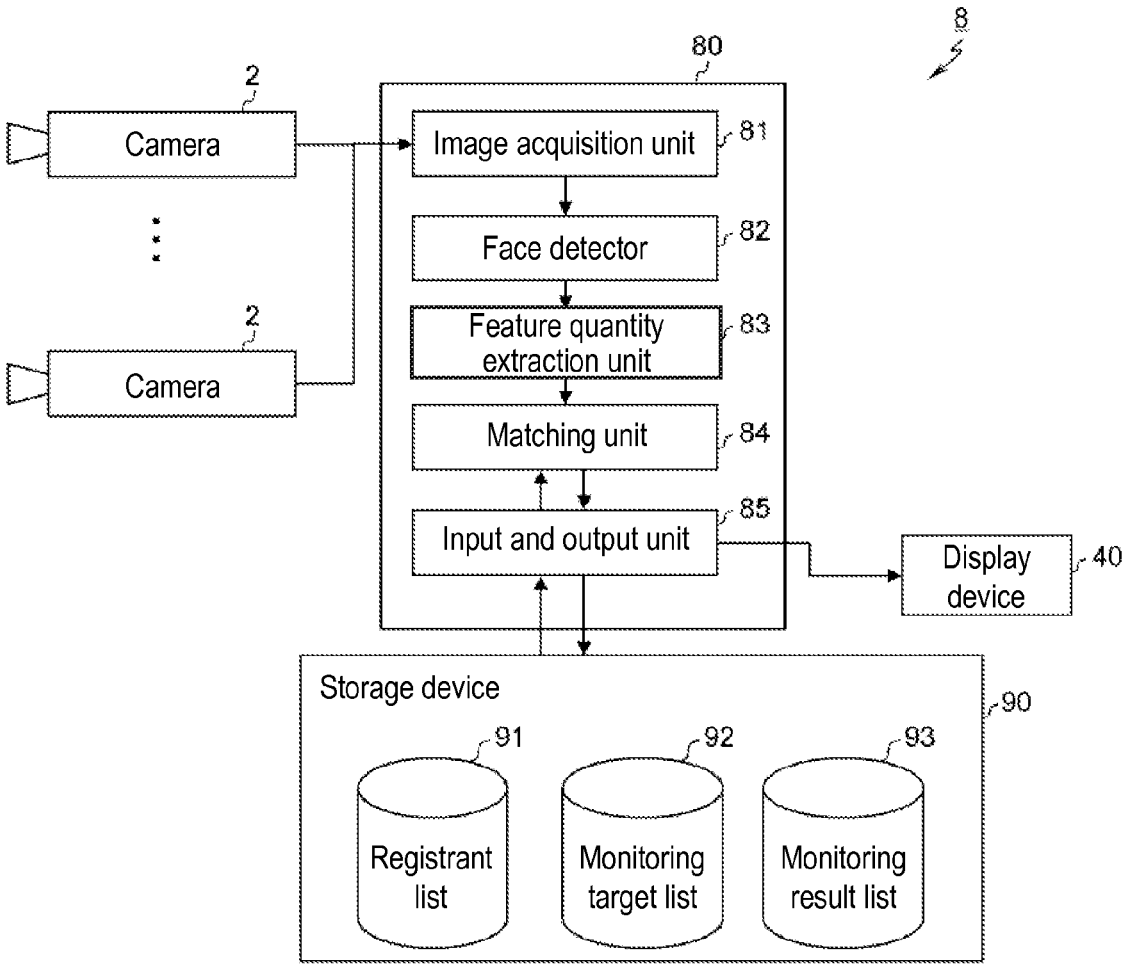

8
80
2
Camera
2
Camera
Image acquisition unit
81
Face detector
82
Feature quantity extraction unit
83
Matching unit
84
Input and output unit
85
Display device
40
Storage device
90
91
92
93
Registrant list
Monitoring target list
Monitoring result list

FIG. 9

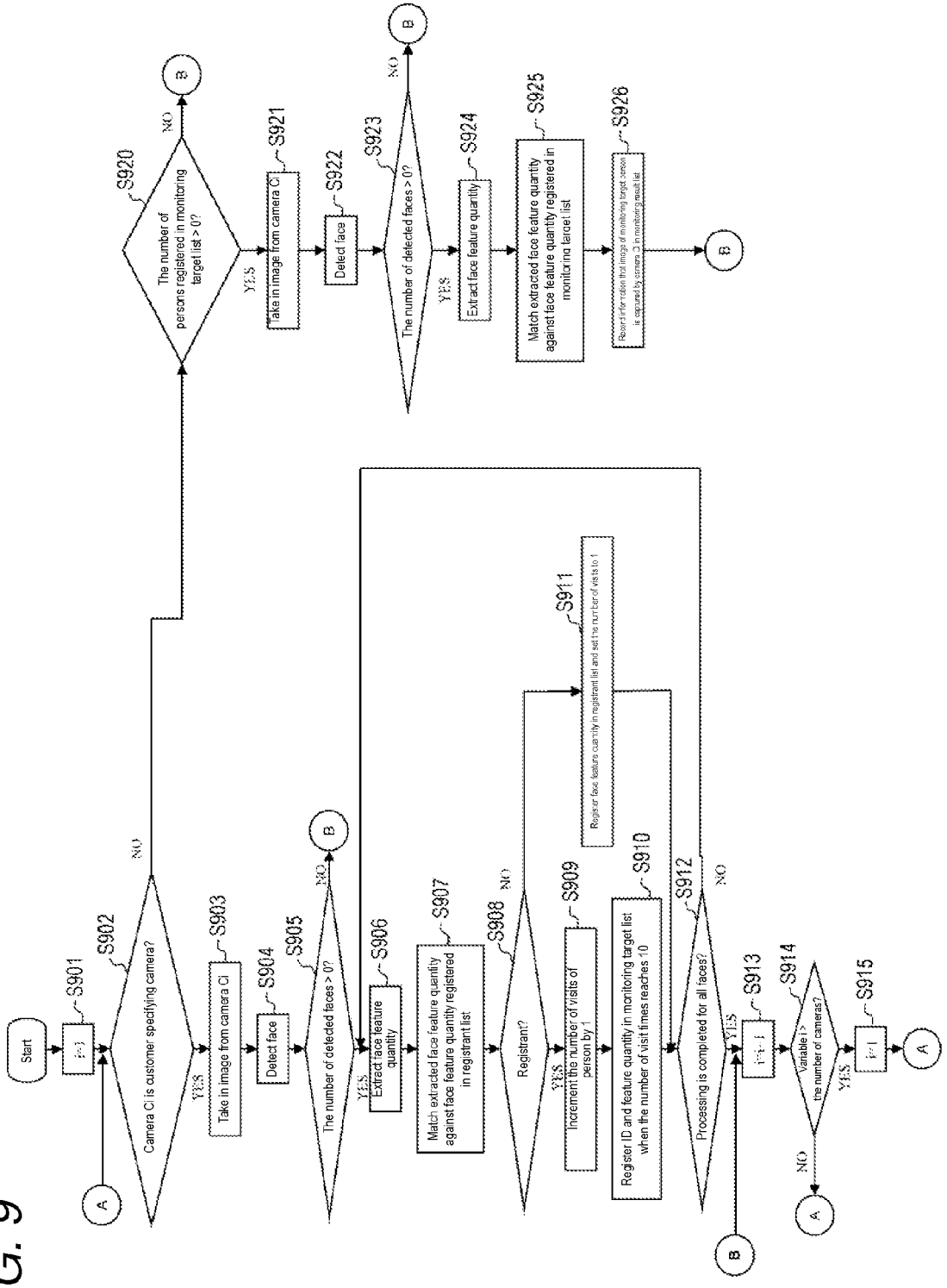

Start
S901
S902
Camera Ci is customer specifying camera?
YES
NO
S903
Take in image from camera Ci
S904
Detect face
S905
The number of detected faces > 0?
YES
NO
S906
Extract face feature quantity
S907
Match extracted face feature quantity against face feature quantity registered in registrant list
S908
Registrant?
YES
NO
S909
Increment the number of visits of person by 1
S910
Register ID and feature quantity in monitoring target list when the number of visit times reaches 10
S911
Register face feature quantity in registrant list and set the number of visits to 1
S912
Processing is completed for all faces?
YES
NO
S913
S914
Variable i > the number of cameras?
NO
YES
S915
S920
The number of persons registered in monitoring target list > 0?
YES
NO
S921
Take in image from camera Ci
S922
Detect face
S923
The number of detected faces > 0?
YES
NO
S924
Extract face feature quantity
S925
Match extracted face feature quantity against face feature quantity registered in monitoring target list
S926
Record information that image of monitoring target person is captured by camera Ci in monitoring result list
A
B

FIG. 10

Date	Clock time	Target person ID	Camera ID	Remarks
2013/6/15	10:02	003	C4	Sales section △△
2013/6/15	10:05	001	C4	Sales section △△
2013/6/15	10:07	003	C2	Sales section ○○
2013/6/15	10:10	002	C5	Sales section □□
2013/6/15	10:12	001	C3	Sales section ××
		...		
2013/6/15	10:35	002	C2	Sales section ○○
		...		

FIG. 11A

ID	Face feature quantity
001	AA1,BB1,CC1,...,XX1
002	AA2,BB2,CC2,...,XX2
003	AA3,BB3,CC3,...,XX3
004	AA4,BB4,CC4,...,XX4
005	AA5,BB5,CC5,...,XX5
...	...

FIG. 11B

ID	Face feature quantity
002	AA2,BB2,CC2,...,XX2
004	AA4,BB4,CC4,...,XX4
005	AA5,BB5,CC5,...,XX5

FIG. 12

ID	Monitoring target flag	Face feature quantity
001		AA1,BB1,CC1,...,XX1
002	1	AA2,BB2,CC2,...,XX2
003		AA3,BB3,CC3,...,XX3
004	1	AA4,BB4,CC4,...,XX4
005	1	AA5,BB5,CC5,...,XX5
...	...	...

MONITORING SYSTEM, MONITORING METHOD, MONITORING PROGRAM, AND RECORDING MEDIUM IN WHICH MONITORING PROGRAM IS RECORDED

CROSS-REFERENCE TO RELATED APPLICATION

This application is based on Japanese Patent Application No. 2013-210759 filed with the Japan Patent Office on Oct. 8, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

The disclosure relates to a monitoring system that monitors a monitoring target area using captured images of the monitoring target area, a monitoring method, a monitoring program, and a recording medium in which the program is recorded.

Nowadays, a monitoring system in which a face recognition technology is used is becoming popular. JP 2007-158421 A discloses an example of the face recognition technology. In the monitoring system, a face feature quantity of a person of a monitoring target is previously stored in a storage, a face area is detected from an input image input from a monitoring camera, a feature quantity is extracted in each face area, the extracted feature quantity is compared to and matched against the face feature quantity stored in the storage, thereby detecting the person of the monitoring target.

When the monitoring system is constructed with a plurality of imaging devices, not only the monitoring is performed at one place, but also when and where the person of the monitoring target exists can be detected at a plurality of places, which allows analysis of a line of movement of the person of the monitoring target.

In the monitoring system, the face feature quantity of the person of the monitoring target is previously stored as a face feature quantity list in the storage, and there is an advantage that a monitoring task can automatically be performed without visual management of an observer. Therefore, the monitoring system is used in not only the monitoring of a suspicious person but also a trend analysis of other persons, such as a good customer in a store.

However, in the monitoring system, with increasing number of persons of the monitoring targets, the number of face feature quantity subject to the matching increases, and therefore unfortunately a load necessary for matching processing and processing time also increase. In practice, this problem should be solved.

An object of the disclosure is to efficiently perform the matching processing even if many possible persons of the monitoring targets exist.

SUMMARY

Specifically, according to a first aspect of the configuration, a monitoring system is configured to monitor a monitoring target area using captured images of the monitoring target area, the monitoring system comprising:

one first imaging device or a plurality of first imaging devices;

one second imaging device or a plurality of second imaging devices;

an image acquisition unit configured to take in images captured by the first imaging device and the second imaging device as an input image;

a face feature quantity extraction unit configured to extract a face feature quantity of a person from the input image;

a storage storing a face feature quantity list, comprising face feature quantities of persons, is stored; and

a matching unit configured to determine whether a person in the input image matches a person of the face feature quantity list by comparing the face feature quantities of the face feature quantity list to the face feature quantity extracted by the face feature quantity extraction unit,

wherein the storage is used to store a first face feature quantity list and a second face feature quantity list therein, the second face feature quantity list is a subset or an empty set of the first face feature quantity list,

the matching unit matches the face feature quantity of the person in the input image against each face feature quantity of the first face feature quantity list when the input image is the image captured by the first imaging device, and the matching unit matches the face feature quantity of the person in the input image against each face feature quantity of the second face feature quantity list when the input image is the image captured by the second imaging device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram schematically illustrating a functional configuration of a monitoring system according to a first embodiment of the disclosure;

FIG. **2** is a diagram illustrating a hardware configuration when the monitoring system is constructed with a general-purpose personal computer;

FIG. **3** is a flowchart illustrating a processing flow in the monitoring system of the first embodiment;

FIG. **4** is a chart schematically illustrating a data structure of a monitoring result list in the first embodiment;

FIG. **5** is a diagram schematically illustrating a functional configuration of a monitoring system according to a second embodiment of the disclosure;

FIG. **6** is a flowchart illustrating a processing flow in a terminal of the second embodiment;

FIG. **7** is a flowchart illustrating a processing flow in a monitoring device of the second embodiment;

FIG. **8** is a diagram schematically illustrating a functional configuration of a monitoring system according to a third embodiment of the disclosure;

FIG. **9** is a flowchart illustrating a processing flow in the monitoring system of the third embodiment;

FIG. **10** is a chart schematically illustrating a data structure of a monitoring result list in the third embodiment;

FIGS. **11**A and **11**B are charts illustrating examples of data structures of a registrant list and a monitoring target list; and

FIG. **12** is a chart illustrating an example of another data structure of the registrant list and the monitoring target list.

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments of the disclosure will be described with reference to the drawings.

<First Embodiment>

(System Configuration)

FIG. **1** is a diagram schematically illustrating a functional configuration of a monitoring system according to a first embodiment of the disclosure. Using a monitoring camera

installed in a facility such as a store or an airport, a monitoring system **1** monitors whether a suspicious person enters the facility or where the suspicious person is in the facility, and alerts a manager as needed. In the first embodiment, by way of example, the monitoring system **1** is introduced to the store having one entrance and one exit.

The monitoring system **1** includes a plurality of cameras **2**, a monitoring device **10**, a storage device **20**, an alarm device **30**, and a display device **40**.

The camera **2** is constructed with a digital video camera or a digital still camera. In the first embodiment, it is assumed that five cameras **2** are connected to the monitoring device **10**. The cameras **2** are distinguished from one another by camera IDs C**1** to C**5**, and it is assumed that the camera C**1** is installed in the entrance, that the camera C**5** is installed in the exit, and that the cameras C**2** to C**4** are installed in different sales sections of the store.

For example, the monitoring device **10** can be constructed with a general-purpose personal computer. FIG. **2** is a diagram schematically illustrating a hardware configuration of the monitoring device **10** when the general-purpose personal computer is used. In the hardware configuration of the monitoring device **10**, a CPU (Central Processing Unit) **41**, a ROM (Read-Only Memory) **42**, a RAM (Random Access Memory) **43**, an HDD (Hard Disk Drive) **44**, and various input devices are connected to one another through a bus. In this case, the display device **40** may double as a monitor **47**.

As illustrated in FIG. **1**, the monitoring device **10** includes an image acquisition unit **11**, a face detector **12**, a feature quantity extraction unit **13**, a matching unit **14**, and an input and output unit **15** as functional elements. In the case that the monitoring device **10** is constructed with the general-purpose personal computer, the CPU **41** executes a monitoring system application program to properly control the ROM **42** and the RAM **43**, thereby implementing the functional elements in FIG. **1**. All or some of the functional elements may be constructed with a dedicated chip (logic circuit). The monitoring device **10** or the monitoring system **1** may be constructed by using one computer of a combination of a plurality of computers or cloud computing.

The image acquisition unit **11** implements a function of taking in an image captured by the camera **2** together with the camera ID.

The face detector **12** implements a function of detecting a face from the image (input image) taken in by the image acquisition unit **11**. Various methods such as template matching and use of luminance gradient information are proposed for detecting the face from the image. However, any method for detecting the face from the image can be used in the disclosure.

The feature quantity extraction unit **13** implements a function of calculating a feature quantity featuring each face detected by the face detector **12**. As used herein, the feature quantity means one in which information of the whole face or a region recognized as eyes, a nose, and/or a mouth in the face of a person included in the captured image is quantified. Examples of the feature quantity include luminance information, frequency characteristic information, and information in which a shape, a position, and a size of the region are digitized.

The matching unit **14** implements a function of comparing the feature quantity calculated by the feature quantity extraction unit **13** to a face feature quantity of a subject registered in a later-described registrant list **21** or monitoring target list **22**, and estimating whether the person in the input image matches any person registered in any of the above-mentioned lists. For example, the matching unit **14** may estimate whether the person in the input image is identical to any person registered in any of the above-mentioned lists.

The input and output unit **15** implements a function of conducting communication with each list stored in the storage device **20**, which includes reading and writing the information from and to each list, and transmitting the information read from each list to the matching unit **14**.

The storage device **20** may be constructed with a file server or an NAS (Network Attached Storage), or the built-in HDD **44** may be used as the storage device **20** in the case that the monitoring device **10** is constructed with the general-purpose personal computer. The storage device **20** is not limited to the configuration of the single HDD, but the storage device **20** may be constructed with a plurality of HDDs.

The registrant list **21**, the monitoring target list **22**, and a monitoring result list **23** are provided in the storage device **20**.

The registrant list **21** is one in which the face feature quantity of a potential monitoring target is stored. In the first embodiment, it is assumed that the face feature quantity of the suspicious person or a person who makes a trouble in the past, together with a registrant ID, are also stored in the registrant list **21**.

The monitoring target list **22** is one in which the face feature quantity of a registrant registered in the registrant list **71** and who is expected to exist in the store is stored at a certain time point during the monitoring. The monitoring target list **22** is empty in an initial state. After the monitoring is started, data (face feature quantity) of the registrant in which the image is captured by the camera C**1** installed in the entrance is copied from the registrant list **21** to the monitoring target list **22** (registration), and the data of the registrant is deleted from the monitoring target list **22** in the case that the image of the registrant is captured by the camera C**5** installed in the exit. The data registered in and deleted from the monitoring target list **22** is described in detail later.

In the first embodiment, the registrant list **21** and the monitoring target list **22** are separately provided as illustrations in FIGS. **11**A and **11**B. Alternatively, for example, the registrant list **21** and the monitoring target list **22** may be provided in a form of one list as illustrated in FIG. **12**, all pieces of data in the list may be used as the registrant list **21**, and the data of the monitoring target flag may be added in order to obtain the monitoring target list **22**.

The monitoring result list **23** is one in which a monitoring result relating to the store is stored. The monitoring result can be recorded in any way. For example, as illustrated in FIG. **4**, an ID of the person detected as the matching result, the camera ID, and a place or behavior of the monitoring target person estimated from the camera ID can be recorded together with a date and time when the matching processing is performed.

For example, the alarm device **30** is constructed with a revolving light or an alarm whistle. Using light or sound, the alarm device **30** notifies a security officer that some sort of affair is generated in the store. In the first embodiment, it is assumed that the alarm device **30** is constructed with the alarm whistle.

For example, the display device **40** is constructed with a liquid crystal monitor. The display device **40** is used when the security officer checks the monitoring result of the store. Examples of a content displayed on the display device **40** include sequential display of the images captured from the

cameras C1 to C5, the flow line of a monitoring target person designated by the security officer, and contents of the monitoring result list **23**.

(Monitoring Processing)

Monitoring processing in the monitoring system **1** will be described below with reference to a flowchart in FIG. **3**.

When the monitoring is started, a camera reference variable i is initialized (Step S**301**). It is then determined whether camera Ci is the camera installed in the entrance (Step S**302**). When the camera Ci is the camera installed in the entrance (YES in Step S**302**), the image acquisition unit **11** takes in the image from the camera Ci (Step S**303**).

The taken-in image is transmitted to the face detector **12**, and the face detector **12** performs face detection processing (Step S**304**). As described above, the face may be detected in any existing way.

When the face is not detected from the taken-in image (NO in Step S**305**), what happens next is that the camera reference variable i is updated to a next value (Steps S**310** to S**312**). On the other hand, when the face is detected from the taken-in image (YES in Step S**305**), the feature quantity is extracted with respect to each detected face (Step S**306**).

Then, the matching processing is performed on the extracted feature quantity using the registrant list **21** (Step S**307**). That is, it is determined whether the detected face matches any of the persons registered in the registrant list **21**.

When the detected face is determined to be one of the registrants registered in the registrant list **21** in the matching processing, the face feature quantity of the registrant is copied from the registrant list **21** to the monitoring target list **22** (registration) (Step S**308**). The fact that the registrant passes the entrance is recorded in the monitoring result list **23** (Step S**309**). During the processing in Step S**309**, if there is a need, a facility manager may be notified by activating the alarm device **30**, or projecting some sort of display on the display device **40**.

When the matching processing is performed to all the faces extracted from the input image, the variable i is incremented, or the variable i is initialized when the variable i exceeds the number of cameras (Steps S**310** to S**312**). Then the flow returns to Step S**302**.

On the other hand, when the camera Ci is not the camera installed in the entrance (NO in Step S**302**), a step to check whether any person is registered in the monitoring target list **22** is performed (Step S**320**). When there is no person registered in the monitoring target list **22** (NO in Step S**320**), the subsequent processing is skipped. In the case that there is no person registered in the monitoring target list **22**, it is considered that no monitoring target person exists in the store.

When there is a person registered in the monitoring target list **22** (YES in Step S**320**), the image is taken in from the camera Ci (Step S**321**), and the face is detected (Step S**322**). When a face or more is detected (YES in Step S**323**), the face feature quantity of each face is also detected (Step S**324**). The processing steps in Steps S**321** to S**324** are identical to those in Steps S**303** to S**306**, and hence detailed description is not repeated.

Then, the matching processing is performed on the extracted feature quantity using the monitoring target list **22** (Step S**325**). That is, it is determined whether the detected face matches any of the monitoring target persons registered in the monitoring target list **22**.

When the detected face is determined to match any of the monitoring target persons registered in the monitoring target list **22** in the matching processing, it is then determined whether the camera Ci is the camera installed in the exit (Step S**326**). When the camera Ci is not the camera installed in the exit (NO in Step S**326**), the information relating to the image of the monitoring target person who is captured by the camera Ci is recorded in the monitoring result list **23** (Step S**328**). When the camera Ci is the camera installed in the exit (YES in Step S**326**), the image of the monitoring target person is regard to be captured by the camera installed in the exit, namely, it is considered that the monitoring target person exits the store. Therefore, the face feature quantity of the monitoring target person is deleted from the monitoring target list **22** (Step S**327**), and the fact that the monitoring target person exits the store is recorded in the monitoring result list **23** (Step S**328**). Similar to the processing in Step S**309**, during the processing in Step S**328**, if needed, the facility manager may be notified by activating the alarm device **30**, or projecting some sort of display on the display device **40**.

When the matching processing is performed to all the faces extracted from the input image, the variable i is incremented, or the variable i is initialized when the variable i exceeds the number of cameras (Steps S**310** to S**312**). Then the flow returns to Step S**302**.

As described above, according to the monitoring system **1** of the first embodiment, only the feature quantity extracted from the image captured by a specific camera (in the first embodiment, the camera C**1**) is matched against all the registrants registered in the registrant list **21**, and the feature quantities extracted from the images captured by other cameras are matched only against the monitoring target person registered in the monitoring target list **22** (that is, a subset of the registrant list **21**) which consists of data that forms only a part of the data stored in the registrant list **21**. Therefore, the processing load necessary for the matching processing can be reduced. Additionally, according to the monitoring system **1** of the first embodiment, the data of the person who is photographed in the image captured by a specific camera (in the first embodiment, the camera C**1**) and registered in the registrant list **21** is automatically registered in (copied to) the monitoring target list **22**, and the data of the person who is photographed in the image captured by a specific camera (in the first embodiment, the camera C**5**) and registered in the monitoring target list **22** is automatically deleted from the monitoring target list **22**. Therefore, the monitoring target list **22** is dynamically constructed, and there is no necessity to manually maintain the monitoring target list **22**, hence a monitoring task can be automated.

<Second Embodiment>

(System Configuration)

FIG. **5** is a diagram schematically illustrating a functional configuration of a monitoring system according to a second embodiment of the disclosure. A monitoring system **5** of the second embodiment includes a monitoring device **50**, a plurality of terminals **60**, and a storage device **70**, and each terminal **60** is connected to the monitoring device **50** through a network.

In the second embodiment, similar to the first embodiment, the monitoring system **5** is introduced to the store having one entrance and one exit by way of example. The monitoring system **5** includes five terminals **60**, and the terminals **60** have respective terminal IDs D**1** to D**5**. It is assumed that the terminal D**1** is installed in the entrance, that the terminal D**5** is installed in the exit, and that the terminals D**2** to D**4** are installed in different sales sections of the store.

The terminal **60** is connected to each camera **2**. Similarly to the first embodiment, the camera **2** is constructed with the digital video camera or the digital still camera. The terminal

60 includes an image acquisition unit 61, a face detector 62, a feature quantity extraction unit 63, and an input and output unit 64 as the functional elements. Because the functions and operations of the image acquisition unit 61, the face detector 62, and the feature quantity extraction unit 63 are similar to the functions and operations of the image acquisition unit 11, the face detector 12, and the feature quantity extraction unit 13 of the first embodiment, the description will not be repeated.

The input and output unit 64 has a function of sequentially transmitting the feature quantity extracted by the feature quantity extraction unit 63 to the monitoring device 50 together with the terminal ID in response to a request from the monitoring device 50.

On the other hand, an input and output unit 52 of the monitoring device 50 receives the feature quantity and the terminal ID, which are transmitted from each terminal 60, and transmits the feature quantity and the terminal ID to the matching unit 51. The input and output unit 52 retrieves data of a registrant list 71 from the storage device 70 to transmit the data to a matching unit 51 in the case that the terminal ID indicates the terminal installed in the entrance, and the input and output unit 52 retrieves data of a monitoring target list 72 to transmit the data to the matching unit 51 in the case that the terminal ID indicates other terminals. The matching processing is described in detail later.

(Matching Processing)

The monitoring processing in the monitoring system 5 will be described below with reference to flowcharts of FIGS. 6 and 7.

FIG. 6 is a flowchart illustrating the matching processing in each terminal Di (i=1 to 5).

When the monitoring is started, each terminal Di waits for a request from the monitoring device 50 (Step S601).

When receiving the request for the transmission of the feature quantity from the monitoring device 50, each terminal Di takes in the image from the camera 2 (Step S602), and performs the face detection processing on the taken-in image (Step S603). When the face is detected (YES in Step S604), the feature quantity extraction processing is performed on the detected face(s) (Step S605). Because the pieces of processing in Steps S603 and S605 are similar to those in Steps S304 and S306 of the first embodiment, the description will not be repeated.

When the feature quantity extraction processing is completed in relation to all the detected face(s), the terminal Di transmits the feature quantity together with the terminal ID through the input and output unit 64 (Step S606). Then the terminal Di returns to the waiting state.

On the other hand, when the face is not detected (NO in Step S604), the terminal Di transmits the information that no face is detected together with the terminal ID through the input and output unit 64 (Step S607). Then the terminal Di returns to the waiting state.

FIG. 7 is a flowchart illustrating the monitoring processing in the monitoring device 50.

When the monitoring is started, the terminal reference variable i is initialized (Step S701). It is then determined whether the terminal Di is the terminal installed in the entrance (Step S702).

When the terminal Di is the terminal installed in the entrance (YES in Step S702), the input and output unit 52 makes a request for the transmission of the feature quantity to the terminal Di (Step S703). When the feature quantity is not included in the information received by the input and output unit 52 (NO in Step S704), the subsequent matching processing is skipped.

When the feature quantity is included in the information received from the terminal Di by the input and output unit 52 (YES in Step S704), the feature quantity is compared to the feature quantity of each registrant registered in the registrant list 71 (Step S705). That is, it is determined whether the person expressed by the transmitted feature quantity is one of the persons registered in the registrant list 71.

When the person expressed by the transmitted feature quantity is determined to be one of the persons registered in the registrant list 71 in the matching processing in Step S705, the face feature quantity of the registrant is copied to (registered in) the monitoring target list 72 (Step S706). The fact that the registrant passes the entrance is recorded in the monitoring result list 73 (Step S707). During the processing in Step S707, if needed, the facility manager may be notified by activating the alarm device 30, or projecting some sort of display on the display device 40.

When the matching processing is performed to all the feature quantities transmitted from the terminal Di, the variable i is incremented, or the variable i is initialized when the variable i exceeds the number of terminals (Steps S708 to S710). Then the flow returns to Step S702.

On the other hand, when the terminal Di is not the terminal installed in the entrance (NO in Step S702), a step of checking whether the person registered in the monitoring target list 72 exists is performed (Step S720). When the person registered in the monitoring target list 72 does not exist (NO in Step S720), the subsequent processing is skipped. In the case that the person registered in the monitoring target list 72 does not exist, it is considered that no person of the monitoring target exists in the store.

When there is a person registered in the monitoring target list 72 (YES in Step S720), the input and output unit 52 makes the request for the transmission of the feature quantity to the terminal Di (Step S721).

Then, using the monitoring target list 72, the matching processing is performed om the feature quantity received by the input and output unit 52 (Step S723). That is, it is determined whether the detected face is one of the faces of the monitoring target persons registered in the monitoring target list 72.

When the detected face is determined to be one of the faces of the monitoring target persons registered in the monitoring target list 72 in the matching processing in Step S723, it is then determined whether the terminal Di is the terminal installed in the exit (Step S724). When the terminal Di is not the terminal installed in the exit (NO in Step S724), the information that the image of the monitoring target person is captured by the camera connected to the terminal Di is recorded in the monitoring result list 73 (Step S726). When the terminal Di is the terminal installed in the exit (YES in Step S724), it is considered that the image of the monitoring target person is captured by the camera connected to the terminal Di installed in the exit, namely, it is considered that the monitoring target person exits the store. Therefore, the data of the monitoring target person is deleted from the monitoring target list 72 (Step S725), and the fact that the monitoring target person exits the store is recorded in the monitoring result list 73 (Step S726). Similar to the processing in Step S707, during the processing in Step S726, if needed, the facility manager may be notified by activating the alarm device 30, or projecting some sort of display on the display device 40.

When the matching processing is performed on all the faces extracted from the input image, the variable i is incremented, or the variable i is initialized when the variable

i exceeds the number of cameras (Steps S708 to S710). Then the flow returns to Step S702.

As described above, according to the monitoring system **5** of the second embodiment, only the feature quantity extracted from the image captured by a specific camera (in the second embodiment, the camera connected to the terminal D1) is matched against all the registrants registered in the registrant list **71**, and the feature quantities extracted from the images captured by other cameras are matched only against the monitoring target person registered in the monitoring target list **72** (that is, a subset of the registrant list **71**) which consists of data that forms only a part of the data stored in the registrant list **71**. Therefore, the processing load necessary for the matching processing can be reduced. Additionally, similarly to the first embodiment, according to the monitoring system **5** of the second embodiment, the data of the person who is photographed in the image captured by a specific camera (in the second embodiment, the camera connected to the terminal D1) and registered in the registrant list **71** is automatically registered in (copied to) the monitoring target list **72**, and the data of the person who is photographed in the image captured by a specific camera (in the second embodiment, the camera connected to the terminal D5) and registered in the monitoring target list **72** is automatically deleted from the monitoring target list **72**. Therefore, the monitoring target list **72** is dynamically constructed, and there is no necessity to manually maintain the monitoring target list, hence the monitoring task can be automated.

In the second embodiment, because of the configuration provides for the plurality of terminals **60** which are connected to the monitoring device **50**, the monitoring system **5** is suitable for use in places such as a large-scale facility and a chain store.

<Modifications>

In the first and second embodiments, the storage device **20** and the storage device **70** are directly connected to the monitoring device **10** and the monitoring device **50**, respectively. Alternatively, the storage device **20** and the storage device **70** may be connected to the monitoring device **10** and the monitoring device **50**, receptively, through the network.

In the first and second embodiments, the information of the person captured by the camera installed in the exit is deleted from the monitoring target list **22** or the monitoring target list **72**. Alternatively, this configuration may be removed, and the face feature quantity of the person may be eliminated from the monitoring target list **22** or the monitoring target list **72** after a given time elapses since the image of the person disappears from all the cameras, or all the pieces of data of the person captured by the camera installed in the exit may be deleted from the monitoring target list **22** or the monitoring target list **72** at a predetermined clock time (for example, closing time).

<Third Embodiment>

(System Configuration)

FIG. **8** is a diagram schematically illustrating a functional configuration of a monitoring system according to a third embodiment of the disclosure. A monitoring system **8** of the third embodiment may be used for various purposes, such as to monitor an existence of a good customer in a facility (such as the store) by using the monitoring camera installed in the facility.

The monitoring system **8** includes the plurality of cameras **2**, a monitoring device **80**, a storage device **90**, and the display device **40**.

Similar to the first and second embodiments, the camera **2** is constructed with the digital video camera or the digital still camera. In the third embodiment, it is assumed that the five cameras **2** are connected to the monitoring device **80**. The cameras **2** are distinguished from one another by camera IDs C1 to C5, and it is assumed that the camera C1 is installed in a sales section for the purpose of specifying a customer, and that the cameras C2 to C5 are installed in different sales sections of the store to monitor the specified customer. However, the camera C1 may be installed in a same place as that of one of the cameras C2 to C5 (for example, the entrance or a cash desk).

Similar to the first and second embodiments, the monitoring device **80** can be constructed, for example, with the general-purpose personal computer. In the case that the general-purpose personal computer is used, the description is not repeated because the hardware configuration of the monitoring device **80** is similar to that of the first embodiment in FIG. **2**.

As illustrated in FIG. **8**, the monitoring device **80** includes an image acquisition unit **81**, a face detector **82**, a feature quantity extraction unit **83**, a matching unit **84**, and an input and output unit **85** as the functional elements. Because the functions of the image acquisition unit **81**, the face detector **82**, the feature quantity extraction unit **83**, the matching unit **84**, and the input and output unit **85** are similar to those of the image acquisition unit **11**, the face detector **12**, the feature quantity extraction unit **13**, the matching unit **14**, and the input and output unit **15** of the first embodiment, the description is not repeated.

The hardware configuration of the storage device **90** is similar to that of the storage device **20** of the first embodiment.

A registrant list **91**, a monitoring target list **92**, and a monitoring result list **93** are provided in the storage device **90**.

The registrant list **91** is one in which the face feature quantity of a potential monitoring target is stored. In the third embodiment, it is assumed that the face feature quantities of all the persons who visit the store are stored in the registrant list **91** together with a registrant ID, the number of visit times, and a date of last visit.

The monitoring target list **92** is one in which the face feature quantity of the registrant (such as the good customer) is stored at a certain time point during the monitoring. The monitoring target list **92** is empty in the initial state. After the monitoring is started, the data of the registrant captured in an image by the camera C1 and satisfying a predetermined condition is copied from the registrant list **91** to the monitoring target list **92** (registration) as good customer data. The data registered in and deleted from the monitoring target list **92** is described in detail later.

The monitoring result list **93** is one in which the monitoring result of the store is stored. The monitoring result can be recorded in any way. In the third embodiment, as illustrated in FIG. **10**, it is assumed that the ID of the person detected as the matching result, the camera ID, and the place of the monitoring target person estimated from the camera ID, are recorded together when the matching processing is performed.

For example, the display device **40** is constructed with the liquid crystal monitor. The display device **40** is used when a sales staff checks the monitoring result of the store. Examples of the content that is displayed on the display device **40** include the sequential display of the images captured from the cameras C1 to C5, the line of movement of the monitoring target person (designated by the sales staff), and the contents of the monitoring result list **93**.

(Monitoring Processing)

The monitoring processing of the monitoring system **8** will be described below with reference to a flowchart in FIG. **9**.

When the monitoring is started, the camera reference variable i is initialized (Step S**901**). It is then determined whether the camera Ci is the customer specifying camera (Step S**902**). When the camera Ci is the customer specifying camera (YES in Step S**902**), the image acquisition unit **81** takes in the image from the camera Ci (Step S**903**).

The taken-in image is transmitted to the face detector **82**, and the face detector **82** performs the face detection processing (Step S**904**).

When the face is not detected from the taken-in image (NO in Step S**905**), the subsequent face matching processing is skipped and the camera reference variable i is updated to a next value (Steps S**912** to S**915**). On the other hand, when the face is detected from the taken-in image (YES in Step S**905**), the feature quantity is extracted with respect to the detected face (Step S**906**).

Then, the matching processing is performed on the extracted feature quantity using the registrant list **91** (Step S**907**). That is, it is determined whether the detected face is one of the persons registered in the registrant list **91**.

When the detected face is determined to be one of the registrants registered in the registrant list **91** in the matching processing (YES in Step S**908**), and if the last visit of the registrant is not the current day, the number of visits of the registrant is incremented by 1 (Step S**909**). When the number of visit times of the registrant reaches a predetermined value, such as 10, the face feature quantity of the registrant is copied from the registrant list **91** to the monitoring target list **92** (registration) (Step S**910**).

On the other hand, when the face is determined to be not any one of the registrants registered in the registrant list **91** in the matching processing (NO in Step S**908**), the face feature quantity is registered in the registrant list **91**, and the number of visits is set to 1 (Step S**911**).

When the matching processing is performed on all the faces extracted from the input image (YES in Step S**912**), the variable i is incremented, or the variable i is initialized when the variable i exceeds the number of cameras (Steps S**913** to S**915**). Then the flow returns to Step S**902**.

On the other hand, when the camera Ci is not the customer specifying camera (NO in Step S**902**), a step to check whether there is any person registered in the monitoring target list **92** is performed (Step S**920**). When no person is registered in the monitoring target list **92** (NO in Step S**920**), the subsequent processing is skipped. In the case that there is no person registered in the monitoring target list **92**, it is considered that the monitoring target customer (such as a good customer) does not exist in the store.

When there is at least a person registered in the monitoring target list **92** (YES in Step S**920**), the image is taken in from the camera Ci (Step S**921**), and the face is detected (Step S**922**). When the face is detected (YES in Step S**923**), the face feature quantity of each face is detected (Step S**924**). The pieces of processing in Steps S**921** to S**924** are identical to those in Steps S**303** to S**306** in the first embodiment, and therefore the detailed description is not repeated.

Then, the matching processing is performed on the extracted feature quantity using the monitoring target list **92** (Step S**925**). That is, it is determined whether the detected face is one of the monitoring target persons registered in the monitoring target list **92**.

When the detected face is determined to be one of the monitoring target persons registered in the monitoring target list **92** in the matching processing, the information relating to the image of the monitoring target person who is captured by the camera Ci is recorded in the monitoring result list **93** (Step S**926**).

When the matching processing is performed on all the faces extracted from the input image, the variable i is incremented, or the variable i is initialized when the variable i exceeds the number of cameras (Steps S**912** to S**915**). Then the flow returns to Step S**902**.

As described above, according to the monitoring system **8** of the third embodiment, only the feature quantity extracted from the image captured by a specific camera (in the third embodiment, the camera C**1**) is matched against all the registrants registered in the registrant list **91**, and the feature quantities extracted from the images captured by other cameras are matched only against the monitoring target person registered in the monitoring target list **92** (that is, a subset of the registrant list **91**) which consists of data that forms only a part of the data stored in the registrant list **91**. Therefore, the processing load necessary for the matching processing can be reduced.

In the third embodiment, the face feature quantity of the monitoring target list **92** is not deleted, but the person whose number of visits reaches the predetermined number of times is registered in the monitoring target list **92**. Alternatively, the face feature quantity of the monitoring target list **92** may be deleted on one or more conditions. For example, the data of the person indicating that the number of elapsed days from the date of last visit is greater than or equal to a predetermined number of days (that is, the number of days the person has not visited the store) may be deleted from the monitoring target list **92**.

In the third embodiment, the person whose number of visits reaches the predetermined number of times is automatically registered in the monitoring target list **92**. Alternatively, the sales staff may manually register the face feature quantity from the registrant list **91** (such as a list of all the customers) in the monitoring target list **92**.

In the disclosure, in order to achieve the object, monitoring is performed on fewer number of persons as compared to the number of possible monitoring target persons.

According to the above configurations, the monitoring system includes the first face feature quantity list and the second face feature quantity list that is of the subset or the empty set of the first face feature quantity list, and the person in the image captured by the second imaging device is matched against the second face feature quantity list (that is, the matching is performed on less number of feature quantities than the number of feature quantities registered in the first face feature quantity list). Therefore, with respect to the image captured by the second imaging device, a processing load in the matching processing is reduced and there is a shortening of the time necessary for the matching.

There are various methods for producing the second face feature quantity list. For example, according to the disclosure, the monitoring system may include a monitoring target person information input and output unit. In such monitoring system, the monitoring target person information input and output unit may register a face feature quantity of a person of the first face feature quantity list in the second face feature quantity list, when the input image is the image captured by the first imaging device, and a person in the input image is determined to be the person of the first face feature quantity list as a result of matching the face feature quantity of the person in the input image against each face feature quantity of the first face feature quantity list. Alternatively, the monitoring system may further include a monitoring target

person information input and output unit. In the monitoring system, the monitoring target person information input and output unit may register a face feature quantity of a person of the first face feature quantity list in the second face feature quantity list, when the input image is the image captured by the first imaging device, a person in the input image is determined to be the person of the first face feature quantity list as a result of matching the face feature quantity of the person in the input image against each face feature quantity of the first face feature quantity list, and the number of times the person in the input image is determined to be the person of the first face feature quantity list is greater than or equal to a predetermined number of times. Accordingly, only the face feature quantity of the person who passes through a specific place or satisfies a specific condition is registered from the first face feature quantity list into the second face feature quantity list, and the second face feature quantity list includes only the person who really needs to be monitored and the second face feature quantity list can be produced dynamically.

According to the disclosure, the monitoring system may further include one or a plurality of third imaging devices. In such monitoring system, the matching unit may match a face feature quantity of a person in the input image against each face feature quantity of the second face feature quantity list when the input image is an image captured by the third imaging device, and the monitoring target person information input and output unit may delete the face feature quantity of the person of the second face feature quantity list from the second face feature quantity list, when the person in the input image captured by the third imaging device is determined to be the person of the second face feature quantity list as a result of matching of the face feature quantity of the person in the input image captured by the third imaging device against each face feature quantity of the second face feature quantity list. Alternatively, in the monitoring system, the monitoring target person information input and output unit may delete all the face feature quantities of the second face feature quantity list at a previously-set clock time. Accordingly, the face feature quantity of the person who is not required to be monitored is deleted from the second face feature quantity list, any increase of the amount of data in the second face feature quantity list is prevented, and any increase of the time necessary for the matching is also prevented.

According to a second aspect of the disclosure, a monitoring method in which a monitoring system including a first face feature quantity list and a second face feature quantity list that is of a subset or an empty set of the first face feature quantity list monitors a monitoring target area using an image captured by an imaging device that is installed so as to partially capture the monitoring target area, and the monitoring method includes the steps of: taking in the image captured by the imaging device as an input image; extracting a face feature quantity of a person from the input image; and matching the face feature quantity extracted from the input image against each face feature quantity of the first face feature quantity list when the input image is an image captured by an imaging device satisfying a predetermined condition, and matching the face feature quantity of the person in the input image against each face feature quantity of the second face feature quantity list when the input image is an image captured by an imaging device except the imaging device satisfying the predetermined condition.

The monitoring method of the second aspect may further include the step of producing the second face feature quantity list as a subset of the first face feature quantity list. Particularly, in the monitoring method of the second aspect, in the step of producing the second face feature quantity list as the subset of the first face feature quantity list, the second face feature quantity list may be produced as the subset of the first face feature quantity list by registering the face feature quantity of the person of the first face feature quantity list in the second face feature quantity list, when the input image is the image captured by the imaging device satisfying the predetermined condition, and the person in the input image is determined to be a person of the first face feature quantity list as a result of matching the face feature quantity extracted from the input image captured by the imaging device satisfying the predetermined condition against each face feature quantity of the first face feature quantity list.

According to a third aspect of the disclosure, the disclosure includes a program configured to cause a computer, the computer configured to be able to use a first face feature quantity list and a second face feature quantity list that is of a subset or an empty set of the first face feature quantity list, to perform the steps of: taking in an image captured by an imaging device as an input image; extracting a face feature quantity of a person from the input image; and matching the face feature quantity extracted from the input image against each face feature quantity of the first face feature quantity list when the input image is an image captured by an imaging device satisfying a predetermined condition, and matching the face feature quantity of the person in the input image against each face feature quantity of the second face feature quantity list when the input image is an image captured by an imaging device except the imaging device satisfying the predetermined condition.

According to a fourth aspect of the disclosure, the disclosure includes a program configured to cause a computer, the computer configured to be able to use a first face feature quantity list and a second face feature quantity list that is of a subset or an empty set of the first face feature quantity list, to perform the steps of: taking in a face feature quantity extracted by a face feature quantity extraction device; and matching the face feature quantity against each face feature quantity of the first face feature quantity list when the face feature quantity extraction device is connected to an imaging device satisfying a predetermined condition, and matching the face feature quantity against each face feature quantity of the second face feature quantity list when the face feature quantity extraction device is connected to an imaging device except the imaging device satisfying the predetermined condition.

According to a fifth aspect of the disclosure, the program of the third and fourth aspects is non-temporally recorded in a computer-readable recording medium. The above configurations and pieces of processing can be combined as long as technical inconsistency is not generated.

According to the disclosure, even if many possible monitoring target parsons exist, the matching processing is performed fewer monitoring targets. Therefore, the processing load in the matching processing is reduced.

The invention claimed is:

1. A monitoring system configured to monitor a monitoring target area using captured images of the monitoring target area, the monitoring system comprising:

a first imaging device;

a second imaging device;

an image acquisition unit configured to take in images captured by the first imaging device and the second imaging device as an input image;

a face feature quantity extraction unit configured to extract a face feature quantity of a person from the input image;

a storage configured to store a face feature quantity list comprising face feature quantities of persons; a matching unit configured to determine whether a person in the input image matches a person of the face feature quantity list by comparing the face feature quantities of the face feature quantity list to the face feature quantity extracted by the face feature quantity extraction unit; and

a monitoring target person information input and output unit;

wherein:

the storage is configured to store a first face feature quantity list and a second face feature quantity list therein, the second face feature quantity list being a subset or an empty set of the first face feature quantity list;

the matching unit is configured to match the face feature quantity of the person in the input image against each face feature quantity of the first face feature quantity list when the input image is the image captured by the first imaging device, and the matching unit is configured to match the face feature quantity of the person in the input image against each face feature quantity of the second face feature quantity list when the input image is the image captured by the second imaging device; and

the monitoring target person information input and output unit is configured to register a face feature quantity of a person of the first face feature quantity list in the second face feature quantity list, when the input image is the image captured by the first imaging device, a person in the input image is determined to match the person of the first face feature quantity list as a result of matching of the face feature quantity of the person in the input image against each face feature quantity of the first face feature quantity list, and the number of times the person in the input image is determined to match the person of the first face feature quantity list is greater than or equal to a predetermined number of times.

2. The monitoring system according to claim **1**, further comprising:

a third imaging device;

Wherein:

the image acquisition unit is further configured to take in images captured by the third imaging device as an input image;

the matching unit is configured to match a face feature quantity of a person in the input image against each face feature quantity of the second face feature quantity list when the input image is an image captured by the third imaging device; and

the monitoring target person information input and output unit is configured to delete the face feature quantity of the person of the second face feature quantity list from the second face feature quantity list, when the person in the input image is determined to match the person of the second face feature quantity list as a result of matching the face feature quantity of the person in the input image captured by the third imaging device against each face feature quantity of the second face feature quantity list.

3. The monitoring system according to claim **1**, wherein the monitoring target person information input and output unit is configured to delete all the face feature quantities of the second face feature quantity list at a previously-set clock time.

4. A computer-readable non-transitory recording medium in which a program is stored, wherein the program is configured to cause a computer, the computer configured to be able to use a first face feature quantity list and a second face feature quantity list that is of a subset or an empty set of the first face feature quantity list, to:

take in a face feature quantity extracted by a face feature quantity extraction device; and

match the face feature quantity against each face feature quantity of the first face feature quantity list when the face feature quantity extraction device is connected to an imaging device satisfying a predetermined condition, and match the face feature quantity against each face feature quantity of the second face feature quantity list when the face feature quantity extraction device is connected to an imaging device except the imaging device satisfying the predetermined condition;

wherein:

the second face feature quantity list is produced as the subset of the first face feature quantity list by registering the face feature quantity of the person of the first face feature quantity list in the second face feature quantity list, when the person in the input image is determined to match a person of the first face feature quantity list as a result of matching a number of times the face feature quantity extracted from the input image captured by the imaging device satisfying the predetermined condition against each face feature quantity of the first face feature quantity list, and the number of times is greater than or equal to a predetermined number of times.

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